

# Leaf Cutter Communication Strategy, Skills and Attributes - a Novel Bio-Inspired Intelligent Communication for Computing Research

J. Amudhavel<sup>1\*</sup>, P. Dhavachelvan<sup>2</sup> and R. Baskaran<sup>3</sup>

<sup>1</sup>Department of CSE, SMVEC, Mannadipet Commune, Madagadipet, Puducherry - 605107 Pondicherry, India.

<sup>2</sup>Department of CSE, Pondicherry University, Kalapet, Puducherry - 605014, Pondicherry, India.

<sup>3</sup>Department of CSE, Anna University, Sardar Patel Road, Guindy, Chennai - 600025, India;  
z-E-mail: info.amudhavel@gmail.com, dhavachelvan@gmail.com, baaski@annauniv.edu

## Abstract

**Background/Objectives:** To analyze the behaviors of Leaf Cutter Ants and develop Bio-inspired intelligent communication mechanism for Research in Computing. **Findings:** In this research, the decision making realizations of the foraging ants are methodologically ascertained, collected and imported. Researchers have come across streaks of emergent patterns pertaining to foraging. It can be estimated in brevity that colonial ants possess or are guided by some feedback loops - positive or negative, coupled with individual responses arbitrated by social behavior of foraging ants and justifiable integrations of effacing local information during the phase of food collection after scrutiny and analysis of colony conditions. **Applications/Improvements:** The behavioral demeanor of ants relies largely on community building and prosperity, rather than individual optimization. The ants can sense and act differently when they understand that they are being scrutinized. Moreover, the intriguing art of surviving amongst weird environs of harmful parasites merely with the aid of *Streptomyces* can also be artificially implemented for the benefit of humankind in its entirety.

**Keywords:** Bio Inspired, Communication, Computing, Intelligence, Leaf Cutter Ant

## 1. Introduction

The leaf-cutting ants can be attributed as dominant herbivores present in the Neotropics. Over a million workers work in the congregation and in a charismatic decisive vein to draw the crumbs of vegetation to the nests. The basic question that haunts, 'How do millions of ants work in tandem and use organized sets of information to trace which plant has greater likelihood of becoming easy residence of symbiotic fungus?

### 1.1. Symbiosis - A Key to Growth

Besides, during the process of symbolic foraging the adult worker ants draw over 90% of the requisite energy

from available plant sap effusing out of the cut material. Perhaps the creditable fungus garden which acts as sole sources of energy and food for the breed of ants, play a pivotal role in making the ants utilize responsibly, major factions of prevalent plant species<sup>1</sup>. It should be borne in mind that ants are choosy while utilizes leaves for foods; on certain occasions the harvested fragments of plants are incorporated duly into the phenomenal fungus garden, are never eaten or fed upon by the foraging ants. This is further established by the proofs that on many occasions, foraging ants associate with plants that can bring about a maximized growth rate of fungus. This is questionable since the ants associate despite the plant sap being highly unattractive.

\*Author for correspondence

## 1.2. What Affects the Speed of Transit of Vegetation to Fungus Gardens?

Ants know holistic strategies to think or decide almost independently, especially between routine absorption of nutritious plant sap and obtain crumbs for the fungus gardens. Integration and Foraging goes hand-in-glove: both are affected by primary extensive decision making and changes in behavioral patterns during the process. This hypothesizes that the foraging ants intricately takes strategic decisions and thereby bring about the interplay sufficing pertaining to individual and social ideologies pertaining to foraging. Lately in 2013, estimated study has revealed the pivotal roles that foraging ants embark on<sup>2</sup>.

## 1.3. Foraging - A Revolution

The holistic process is indeed a revolution, in order to understand the self-organized endeavors of the foraging ants, especially on the grounds of choosing plants, with subtlety. Preference for a hand few of plant species require rigorous intellect and knowhow. The most intriguing aspect is how does the foraging ants group together, decide, discuss and portray evidences pertaining to right inclusion of holistic decision based on collective patterns, effacing the aspects of self-organizing and regulatory processes, pertaining mainly and vividly to self-organized decisions.

## 2. How Does the Colony of Millions of Worker Ants Communicate Amongst Themselves on Individual Parlance?

A colony of foraging ants communicates glibly to trace suitability of resources, especially upon discovery! It is estimated that the chemical<sup>3</sup> and physical nature of the leaves play a pivotal role in propitious plant selectivity. Being attracted to the leaves for battering them down to crumbs rests primarily on 'decisive insight'! It has been verified with evidences on the microscopy that ants leave chemical trails of the path another worker may take up to reach the plant and break it down! If the ants are polymorphic leaf-cutting in nature, they intend to frequently reach out to the plans with fragments weighing in brief correspondence with the body of the ant foragers.

This can be drawn to a conclusion not only by mere insight by mathematical denouement, which the forag-

ing ants anchor aptly on the edges of the leaves, on their respective hind legs. They nimbly pilot around the leaves while cutting 'arcs' on the leaves, my experimentation revealed. Not all workers sum up the procedure of cutting leaves in a similar vein! Often a number of worker ants cut down leaves as large in size as they are capable of carrying; in fact the load size can be selected by the ants prolifically. Thus some cut by the virtue of their own body sizes whereas others involve flexible load size. This has been cross monitored by scrutinizing *Acromyrmex lundi* that prefers in cutting larger or heavier fragments if the source for the fungus garden exists far too away from their nests.

## 2.1. Atta and Fungus: A Revolutionary Association Unraveled

Atta cephalotes carried out the process in a distinct way. It was however found that there was no negative correlation existing between the area density and fragment size! Off late as the promises of symbiotic relationship between Atta cephalotes and the fungus garden gains prominence in terms of data collected, the following finding may be more than sufficient to stop niggling out the self-organized nature of the transit!

The foraging ants not only collect food but also transmit information pertaining to the locality of reference and quality<sup>4-6</sup>. With the likelihood of finding the innate challenges associated with generating biofuel or anticancer drugs from the fungus garden over a few months, the recent researchers have rendered the utility of innovative insights pertaining to the food collection behavior and sound recruitment behavior in acquiring food or opting to recruit nestmates. In another attempt an experiment was carried out to trace whether information obtained from chemical trails, regarding source of quality food and hiring a capable recruitment communication, under the constrained experimental condition affect the behavior of the individual and thereby the colony function. The recruited workers behaved in a different vein! After being informed that the source of food was varied, the responses to stimuli for the blogger confronted some standardized stimuli!

## 2.2. Experiments Hold Testimony That Leaf Cutters Have Intellect

This experimental approach projected a rationale that reads: On certain occasions or assays, the established leaf

cutters (here, the subject being *Acromyrex lundii*)<sup>7</sup> were nominally exposed to sucrose in droplets of 1% - 10% of sucrose solution to detect how it affected other worker ants to follow the trail<sup>5</sup>! Interestingly as and when the involved recruiter workers arrived, they were attracted not to sucrose but more vividly to parafilm (impregnated with sucrose), that lacked sugar! All and sundry found this as the sole principle followed by recruiter workers to follow by the standard and not be swayed away thereby creating ruckus.

Lately, the behavioral patterns and the parameters involved were noticed vividly, that helped one and all to come down to realizations pertaining to the realm of behavioral dynamics, especially in the parlance of 2013. The assorted batch of 10% workers chose to cut down smaller fractions of parafilm and return to the colonies at prettily high velocities. However, the 1% workers chose the alternative; that is they brought larger chunks of parafilm at sturdy pace to the respective colony.

Brows deepened to scowls as in a similar yet different experiment carried out recently, all and sundry was flabbergasted! It was proven that the 10% scouts had a discrepancy in speed and faltered in reaching the colony faster than 1% scouts. Higher velocity, yet lower transport rate, this spreads like a fount-head and discussions kept the corollary at bay, though limited to a mere hypothesis! The failure of this hypothesis asked for further research; soon the fallacy was countered by an 'information transfer hypothesis'!

### 3. Information Transfer Hypothesis: Tested to Perfection in the Laboratory

The emeritus researchers Nunez and Roces proclaimed this Information Transfer Hypothesis way back in 1993. They focused on the foraging behavior of honey bees and studies revealed then and was thoroughly corroborated later that the cutting behavior of the honey bees depended largely on the transfer information. It was the sort of information that affected the bees to an extent that they analyzed the procedure for transfer and considered their cutting behavior and returned to the nest and recruited worker bees in larger numbers so as to accomplish the task early.

According to this theory, the workers were bent on sacrificing its rate of leaf delivery, however the entire

colony in its entirety increases its efficiency in terms of leaf delivery -characterized by reduced leaf fragments coupled with high speed of traveling to and fro from the nests to the targeted area. The hypothesis is what the colonies of ants follow and this has been proved that according to the dialects as proclaimed in the hypothesis, the size of the leaf-fragments do reduce by 10% for each worker however each worker ant can suitably carry out the entire process with 10% more efficiently. The information Transfer Hypothesis earmarked the phenomena of trail-marking behavior as is observed in 10% worker ants<sup>8,9</sup>.

#### 3.1. The Outcome of the Experiment

Close study of the worker ants leaf cutter ants in 2013 further at collective levels proved that changes were perceivable in the foraging behavior of the worker ants once a particular height constraint was placed about 1 centimeter on the area encompassing the trail area linking to the nearby foraging area. During the hours of the survey, it was found that the shapes and sizes of the foraging material that the ants brought back got significantly modified after the constraint was placed upon the trail<sup>10-12</sup>. It was found that the forager leaf cutter ants cut the leaves into rounder and smaller crumbs or fragments, irrespective and independent of their individual sizes. This happening occurred only in the presence of the height of 1 centimeter on the pathway that the ants were following. Removing the height resulted in larger and more pronounced sizes of fragments of leaves. This particular size adjustment was not a sensory feedback, since it occurred when the ants were busy cutting down the leaves into fragments in the foraging area.

What was also analyzed in this study was that the ants brought in double the number of recruiters involved in cutting down and carrying the fragments; this however conveyed clearly that the ants didn't think it necessary to lessen the volumes of fragments that shall reach their nests. They enhanced the recruiters engaged while lessening the size of the fragments in order that the ultimate efficiency of bringing in fragments to the nests doesn't get altered.

This study conducted under guidance with patient surveillance projected that ant colony is a collection of a rare number of intelligent insects who are decisive when in a fix and are quick learners. The ants are great in gelling around with each other at collective levels and they can skillfully adjust them and atone their behaviors as and

when need be with respect to restrictive obstacles. This also reflects exuberant intelligence visible in any swarm.

## 4. A New Dimension: Why Would Ants Need a Constant Flow of Leaf Fragments Despite Odds in the Trail?

A journey to a forest in Montreal was conducted primarily focusing on understanding the degree of stubbornness, intellect and insight among the front-runners of the swarm intelligence, the leaf cutter ant colonies. Before it is well spoken of, the analysis of why do ants need fungus would leave all and sundry bewildered. The ants actually use the tips of fungus for food. The tilling of the fungus and feeding on it brings to the fore another species on this planet, besides human beings, who resort to farming and raise crops for their subsistence. However another question shall be a spot of bother as to how could the ants survive on the fungus, which must have been contaminated with pathogens as the biologists have proclaimed, down the generations?

While trying to decipher instances of collective intelligences in 2013, it was discovered that the fungus farmed by the ants are rich in parasites and bacteria. One of the deadly parasites that were collected in a sample of the fungus was *Escovopsis*. This made it clear that the leaf cutter ants must be emanating or producing some antibiotics that can tone down the effects of the harmful molds.

### 4.1. Demystifying a Relationship between the Leaf Cutters and *L. gongylophorous*

At this juncture it is clear that the ants are not only cognitive and quick decision makers but they also produce antibiotics that protect them from being harmed by all sorts of bacteria and parasites, to mention the least. Now evolves another mystery, laid down by the remarkable discovery<sup>13</sup>. We often complain and the microbiologists or the pathologists re of the view that the human body gets maimed by diseases and consume antibiotics that seems to be quite ineffective after say three or four generations. It is often reported that the disease causing organisms get accustomed and thereby immune against the antibiotics that are prevalent across the world. It was discovered lately that the ants are professional cultivators of the bacteria called *Streptomyces* which is used by human beings

to produce more than half of the drugs prevalent in the pharmaceutical industry. Further analysis projected that the enzymes obtained from the samples of leaf cutter ants resembles all of the known enzymes or at least have similarity with the acknowledged ones. Yet the burning question is how do ants manage to protect themselves with *Streptomyces* for over 65 million years now, when the mortals come up with complaints that the disease causing organisms become immune to the drugs over three of four generations? Rigorous studies of the cognitive sciences that lead the ant colonies coupled with traces of symbiotic relationships of *L. gongylophorous* with the leaf cutter ant *Atta Cephalotes* have been carried out.

### 4.2. Generation of Biofuel - a Rarity

Studies reveal that *L. gongylophorous* produces food for the ants; they develop fruiting bodies that are quite rich in amino acids, fats and such other nutrients. The production can further take place at the advent of sugar that comes from the long cellulose molecules available in the leaf crumbs delivered by the leaf cutter ants. The fungus produces dollops of enzymes that break the cellulose into subunits of glucose. The researchers tried to sequence the genome of *L. gongylophorous*<sup>14</sup> and it was then found out that the cellulose or sugar degradation was primarily being carried out with the aid of specialized enzymes by the *L. gongylophorous*. This characteristically revealed that the fungus' productivity is also owing to the diversity of bacteria prevalent on the fungus gardens. Researches portray that the bacteria too have a large role to play in the ant colonies. The bacteria provide key vitamins and nitrogen and also appear to play a role in helping the fungus have access to energy rich cellulose by literally breaking apart plant polymers like hemicellulose. Thus analyzing the intricacy of the functionality of the leaf cutter ants is indeed beautiful; the colony in fact recluses into a bio-refinery where biofuel is being generated as the fungus in association of the bacteria work on the leaves that the laborious leaf cutter ants bring in. This also portrays that the leaf cutter ants should always keep searching about the strategies which comprise cognitive means to bring about constant supply of fragmented leaves to the nests wherein the process of biofuel generation is taking place.

In order to find the basis of this theory researches were conducted in 2013 on certain species of beetles and termites who exhibit swarm culture and live in colonies. The aggregated inputs can be well copied by the researchers

and devise some strategy to extract, duly replicate and aptly purify biomass degrading enzymes artificially or synthetically. Symbioses between fungus and leaf cutter ants exhibit such a natural process. Replicating such a process on artificial grounds may be tough but perhaps not impossible.

## 5. What Do Ants Do When They Assess That Their Movements are under Scrutiny?

While setting the stage for analyzing and demystifying the behavior of ants, it is highly essential to analyze how the ants' behavior changes when they analyze that their behavior is under scrutiny. Observations of honey bees can be suitably inflicted upon any ants in a similar vein<sup>15</sup>. Researchers have summarized into a generalized statement from the analysis of the behavioral patterns of bees that workers are often affected or laid down by their motivational state of minds that largely depend on the gnawing differences between the quality of resources. In case of honey bees, the flow rates pertaining to the available sugar solutions seemed to affect the measurements among the honey bees. Another question that barges in on one's mind is that why recruited worker ant runs faster when it is informed about the presence of a somewhat richer source of food. This attribute also holds good in explaining the dilemmas that engulf an ant when it comes across information regarding a food source, the information gets transmitted very rapidly<sup>16</sup>.

### 5.1. Rapid Monopoly on a Series of New Discoveries of Food Sources Make Them Their Own.

On further radical analysis it is estimated that perhaps the art of monopolizing over a certain food source is brought about by a pack of ants that follow the initial trails rather too fast, perhaps instigated by tactile stimulation. The ants cater to save time at the initial phase of developing and thereby following a trail, depending upon the information obtained<sup>17</sup>. Once the first set of ants are duly successful in their endeavors, it amplifies the recruitment process: far more workers get recruited; enthused workers follow trail rather fast and it comes to an imperative inference that the decisions of these workers are largely affected by the presumptions of front runner scouts who carried out the initial trail-run, almost impeccably.

Assessment of food source or availability of food from time to time affects instances of inter-individual variances on the premises of decision making<sup>17</sup>! Thus it is clearly portrayed that ants residing in a colonized way, resort to behavioral changes on facing certain dissidences in the sources of food. Not only that, the analysis of the individual behavioral patterns and functioning of colonies. Research conducted at the laboratories reveal that the worker ants follow the principle of optimality theory that can be exemplified by the fact that the ants resort to maximizing outputs of the entire colony as a whole, at the cost of their individual efficiency<sup>18</sup>, in order to leverage the rates of leaf deliveries, on the basis of enhanced energetic efficiencies of the ants.

## 6. Conclusion

It can be ascertained followed by hours of research that the hypothesis of the information transfer theory holds well. Mature colonies of ants prosper by gaining footholds of the new developments or sources of foods. However, the behavioral demeanor of ants relies largely on community building and prosperity, rather than individual optimization<sup>19</sup>. The ants can sense and act differently when they understand that they are being scrutinized. Moreover, the intriguing art of surviving amongst weird environs of harmful parasites merely with the aid of *Streptomyces* can also be artificially implemented for the benefit of humankind in its entirety.

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